



US009205803B2

(12) **United States Patent**
Farooq et al.

(10) **Patent No.:** **US 9,205,803 B2**
(45) **Date of Patent:** **Dec. 8, 2015**

(54) **DEPLOYABLE UPPER LEG STIFFENER FOR PEDESTRIAN PROTECTION**

(71) Applicant: **Ford Global Technologies, LLC,**
Dearborn, MI (US)

(72) Inventors: **Iskander Farooq,** Novi, MI (US);
Mohammed Omar Faruque, Ann Arbor, MI (US)

(73) Assignee: **Ford Global Technologies, LLC,**
Dearborn, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 41 days.

(21) Appl. No.: **14/146,928**

(22) Filed: **Jan. 3, 2014**

(65) **Prior Publication Data**

US 2015/0191145 A1 Jul. 9, 2015

(51) **Int. Cl.**
B60R 21/38 (2011.01)
B60R 21/00 (2006.01)

(52) **U.S. Cl.**
CPC **B60R 21/38** (2013.01); **B60R 2021/0053** (2013.01)

(58) **Field of Classification Search**
CPC .. B60R 21/34; B60R 21/38; B60R 2021/343; B60R 2021/0053; B60R 2021/0055
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,865,014 A * 6/1932 Heinrich 293/45
3,791,468 A 2/1974 Bryan, Jr.
3,829,140 A * 8/1974 Jehu et al. 293/15
3,922,014 A 11/1975 Hinderks

4,093,290 A * 6/1978 Pearson 293/15
4,867,397 A 9/1989 Pamadi et al.
4,904,016 A 2/1990 Tatsumi et al.
4,996,783 A * 3/1991 Fresia 37/245
5,046,768 A * 9/1991 Myslicki 292/68
5,403,059 A 4/1995 Turner
5,458,391 A 10/1995 Ito et al.

(Continued)

FOREIGN PATENT DOCUMENTS

DE 19911833 A1 9/1999
DE 10059202 A1 7/2002

(Continued)

OTHER PUBLICATIONS

Intellectual Property Office, Search Report for the corresponding Great Britain Patent Application No. GB1422829.0 mailed Mar. 9, 2015.

(Continued)

Primary Examiner — Paul N Dickson

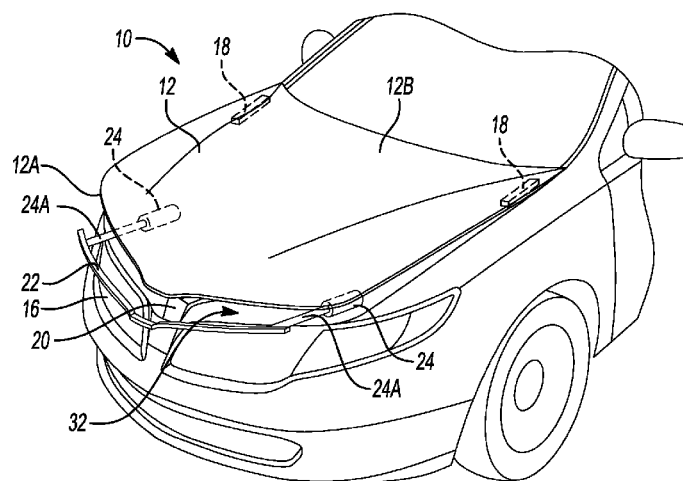
Assistant Examiner — Timothy Wilhelm

(74) *Attorney, Agent, or Firm* — Frank A. MacKenzie;
Brooks Kushman P.C.

(57) **ABSTRACT**

A pedestrian safety system for use with a motor vehicle includes a vehicle hood movable between a closed position and a raised position wherein a leading edge of the hood is raised relative to a front surface of the vehicle to form a gap, and a leg stiffener movable between a retracted position wherein it is beneath the hood when the hood is closed and a deployed position wherein the stiffener projects through the gap and is forward of the leading edge of the hood when the hood is raised. At least one actuator mounted beneath the hood moves the stiffener between the retracted and deployed positions. A remote sensing system detects an impending collision with a pedestrian and triggers the raising of the hood and extension of the actuators.

20 Claims, 3 Drawing Sheets



(56)

References Cited**U.S. PATENT DOCUMENTS**

5,924,756 A 7/1999 Homa
 6,447,049 B1* 9/2002 Tohda et al. 296/180.1
 6,676,179 B2 1/2004 Sato et al.
 6,736,447 B2 5/2004 Angelo et al.
 6,736,449 B2 5/2004 Takahashi et al.
 6,802,556 B2* 10/2004 Mattsson et al. 296/187.09
 7,077,439 B2 7/2006 White et al.
 7,192,079 B2 3/2007 Schramm et al.
 7,331,413 B2 2/2008 Okai et al.
 7,377,580 B1 5/2008 Ekladyous
 7,469,955 B2* 12/2008 Patterson et al. 296/187.03
 7,621,364 B2 11/2009 Haglund
 7,735,902 B2 6/2010 Wurtemberger
 7,740,293 B2 6/2010 Kim
 7,836,996 B2* 11/2010 Kitte et al. 180/271
 7,837,256 B2 11/2010 Takayanagi et al.
 7,845,691 B2 12/2010 Sundararajan et al.
 7,905,314 B2 3/2011 Mathevon et al.
 8,100,444 B2 1/2012 Erzgraeber et al.
 8,141,918 B2 3/2012 Miller et al.

8,210,600 B1 7/2012 Verhee et al.
 8,276,953 B2 10/2012 Erzgraeber et al.
 8,534,410 B2* 9/2013 Nakaura et al. 180/274
 2008/0258489 A1* 10/2008 Ebner et al. 296/77.1
 2010/0230195 A1 9/2010 Ginja et al.
 2010/0244484 A1 9/2010 Nakaura et al.
 2010/0270813 A1* 10/2010 Roth et al. 292/121
 2012/0074715 A1 3/2012 Kim

FOREIGN PATENT DOCUMENTS

DE 10254733 A1 6/2004
 FR 2445783 A1 8/1980
 JP 2007217206 A 8/2007
 WO 2007097641 A1 8/2007
 WO 2008007090 A1 1/2008

OTHER PUBLICATIONS

Peter J. Schuster, Current Trends in Bumper Design for Pedestrian Impact, California Polytechnic State University, Copyright 2008.

* cited by examiner

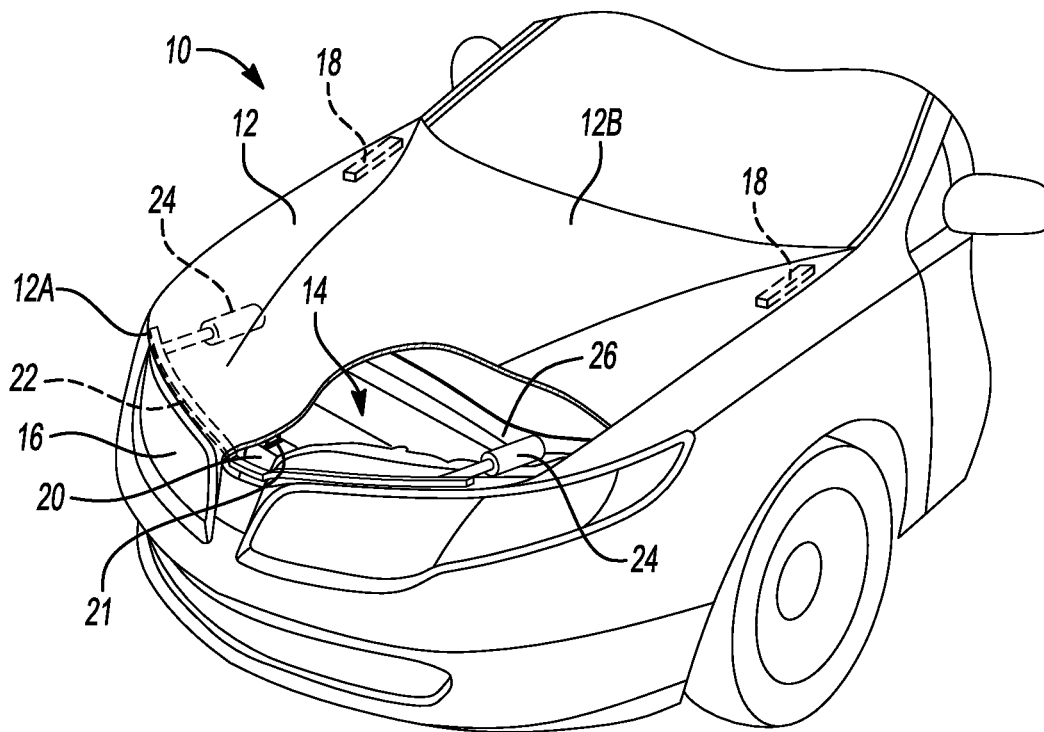


Fig-1

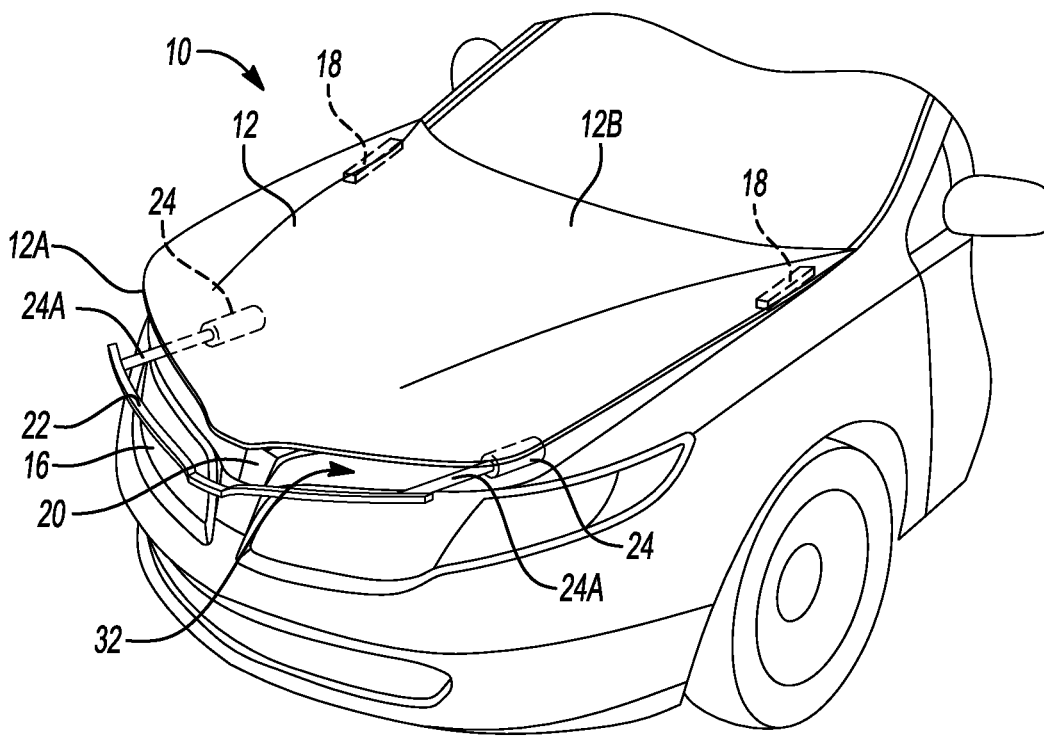


Fig-2

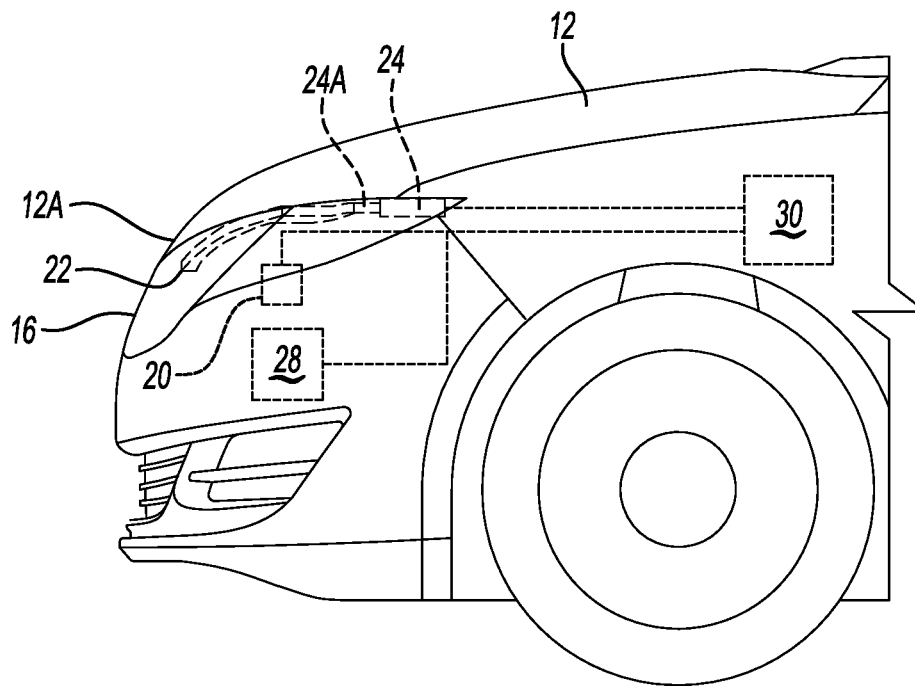


Fig-3

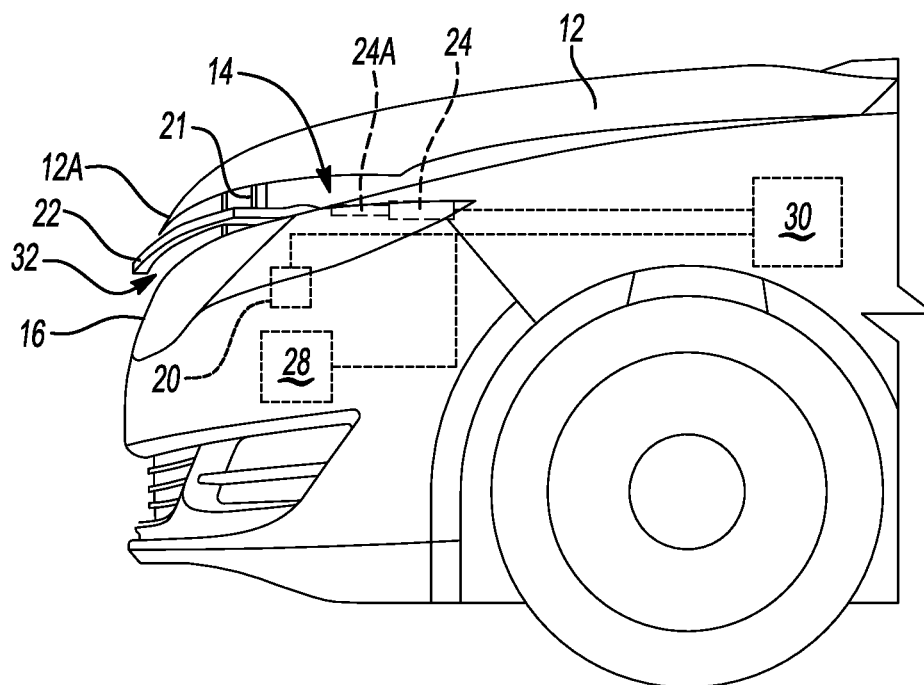
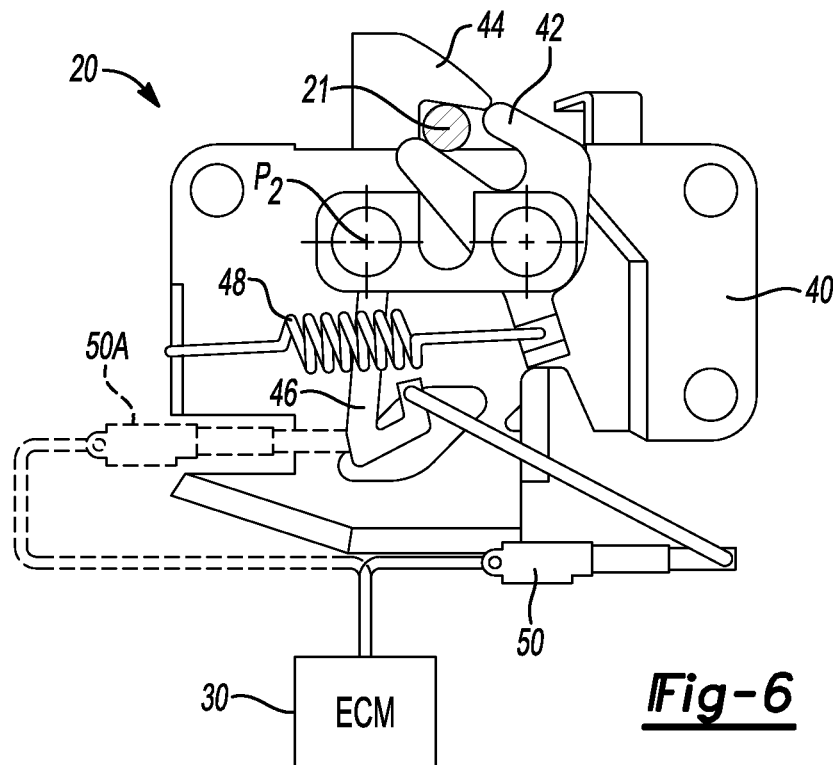
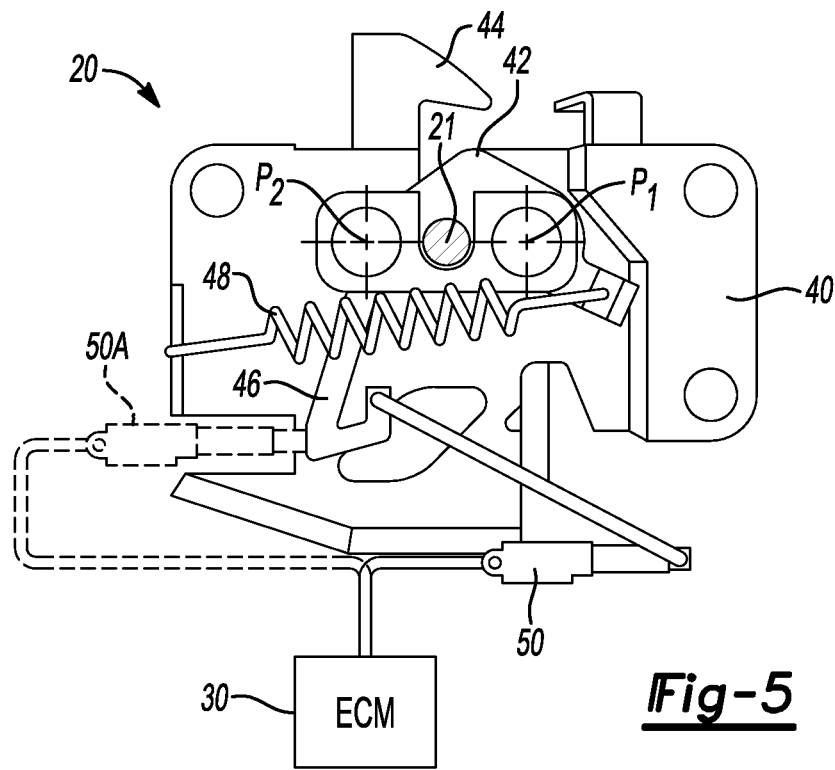


Fig-4



1

DEPLOYABLE UPPER LEG STIFFENER FOR PEDESTRIAN PROTECTION

TECHNICAL FIELD

The present invention relates generally to vehicle-mounted pedestrian protection devices for motor vehicles and, more specifically, to a deployable stiffener for upper leg protection.

BACKGROUND

Several national and multi-national vehicle safety organizations have formulated pedestrian safety standards which new vehicles are measured against. At least one such safety standard utilizes a test procedure which simulates a vehicle striking the upper leg of a pedestrian standing or walking in front of the vehicle. For some vehicle designs, contact with the upper leg is made by the leading edge of the vehicle hood and/or portions of the vehicle immediately below the hood leading edge.

Some motor vehicles have a front-end shape that is relatively low for visibility, aerodynamic, and/or styling reasons. As a result, there may be a relatively small amount of clearance between the front-end panels (hood, fender, grille, head lamps, etc.) and the vehicle's structural frame and/or other rigid components (powertrain, suspension, etc.) beneath the panels (within the engine bay, for example). In general, more clearance is believed to improve pedestrian safety because it provides "crush space" through which the relatively deformable front-end panels can deflect when struck by a pedestrian. Exterior panel deformation absorbs kinetic energy of the collision before the pedestrian strikes the rigid components inside the vehicle front-end.

It has been proposed to increase the under-hood crush space by raising or lifting the vehicle hood from its normal operating position immediately prior to a pedestrian impact. Known systems include crash detection and/or prediction sensors that trigger actuators which adjust the position of the hood in reaction to the detected/predicted impact. Raising the vehicle hood, however, may not provide sufficient reduction in severity of injury caused by the leading edge of the hood striking the pedestrian's upper leg.

U.S. Pat. No. 7,845,691B2 discloses a pedestrian safety system in which a pedestrian collision sensing device activates a hood release and a lifting actuator to raise the hood to a raised condition, thereby providing additional deformation space beneath the hood.

SUMMARY

In an embodiment disclosed herein, apparatus for a motor vehicle comprises a hood movable between a closed condition and a raised condition in which a gap is formed between a leading edge of the hood and a front surface of the vehicle (such as a grille), and a leg stiffener movable between a retracted position wherein it is beneath the hood in the closed condition and a deployed position wherein it projects through the gap and is forward of the hood leading edge. When in the deployed position, the stiffener provides an improved transfer of kinetic energy to the upper leg of a pedestrian struck by the vehicle so as to reduce the likelihood and/or severity of injury.

In another embodiment disclosed herein, a safety system for use with a motor vehicle comprises a hood movable between a closed position and a raised position wherein a leading edge of the hood is raised relative to a front surface of the vehicle to form a gap, a leg stiffener movable between a retracted position wherein it is beneath the hood when the

2

hood is closed and a deployed position wherein the stiffener projects through the gap and is forward of the leading edge of the hood when the hood is raised, at least one actuator moving the stiffener between the retracted and deployed positions, and a remote sensing system detecting an impending collision with a pedestrian and triggering the actuators.

The actuator may be electromechanical, pneumatic, or pyrotechnic, and may be resettable to return the stiffener to the retracted position after deployment. The actuators are mounted to structure of the vehicle beneath the hood, such as a radiator support bracket.

In another embodiment disclosed herein, apparatus for use with a hood of a motor vehicle comprises a leg stiffener mounted beneath the hood and movable relative to the vehicle between a retracted position beneath the hood when the hood is closed and a deployed position extending forward of a leading edge of the hood when the hood is raised.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a schematic perspective view of a front portion of a motor vehicle with a leg spoiler in a retracted position;

FIG. 2 shows a schematic perspective view of the motor vehicle of FIG. 1 with the leg spoiler in a deployed position;

FIG. 3 shows a schematic side view of a front portion of a motor vehicle with a leg spoiler in a retracted position;

FIG. 4 shows a schematic side view of the motor vehicle of FIG. 3 with the leg spoiler in a deployed position;

FIG. 5 shows a schematic view of an active hood latch actuator holding a hood in a closed condition; and

FIG. 6 shows a schematic view of the active hood latch actuator of FIG. 5 holding the hood in a raised condition.

DETAILED DESCRIPTION

As required, detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely exemplary of the invention that may be embodied in various and alternative forms. The figures are not necessarily to scale; some features may be exaggerated or minimized to show details of particular components. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art to variously employ the present invention.

FIG. 1 depicts the forward portion of a vehicle 10 having a hood 12 covering an engine compartment 14. Hood 12 is shown in a closed condition wherein a leading edge 12A of the hood is disposed immediately above a front surface of the vehicle to present a substantially unbroken, aerodynamic contour. The front surface of the vehicle below leading edge 12A may comprise, for example, an ornamental or functional grille 16. Hood 12 is connected to the body of the vehicle 10 by hinges 18 which may be located adjacent to a rear edge 12B of the hood.

Hood 12 is shown as a single component for simplify of illustration but, as is well known in the art, normally comprises two or more layers of steel, aluminum, fiberglass, or other composite material secured together.

A latch mechanism 20 (shown in greater detail in FIGS. 5, 6) is disposed beneath hood 12 and adjacent to leading edge 12A and selectively engages a striker 21 secured to the interior (lower) surface of hood 12. Latch mechanism 20 operates to alternatively a) retain the hood in the fully closed condition (FIG. 1), and b) allow the leading edge 12A to move upward at least as far as the raised condition (FIG. 2). Latch mecha-

nism **20** may also be operative to apply an upward force to raise the hood **12** to the raised condition. Such an “active” hood latch is disclosed in U.S. Pat. No. 7,845,691B2, the disclosure of which is incorporated herein by reference. Latch mechanism **20** may be further operable to completely release hood **12** so that the hood **12** so that it may be fully opened (not shown).

Hinges **18** permit hood leading edge **12A** to move upwardly relative to the vehicle **10** at least as far as the raised condition, wherein a relatively narrow gap **32** exists between hood leading edge **12A** and grille **16**. Hinges **18** may be configured to allow hood rear edge **12B** to lift, rather than simply pivoting about the hinge. Hinges **18** may further permit movement of the hood to a fully opened position (not shown) to provide access to the engine compartment for maintenance, servicing, inspection, or other purposes. Alternatively, a separate hinge or hinges (not shown) may be provided that allow hood **12** to open fully.

A leg stiffener **22** is located immediately beneath the forward portion of hood **12**. When in a retracted position (which coincides with hood **12** being in its closed condition, see FIGS. **1** and **3**), stiffener **22** is beneath and closely adjacent to hood leading edge **12A** and is substantially enclosed by the hood. During normal vehicle operation, hood **12** is in the closed condition and stiffener **22** is in the retracted position. “Normal vehicle operation” is hereby defined as prior to a detected or predicted collision with a pedestrian.

Stiffener **22** is mounted to left and right actuators **24** which are mounted to vehicle structure beneath the hood **12**, such as radiator support structure **26**. Actuators **24** may be mounted to any appropriate under-hood vehicle structure in or near the engine compartment **14** without departing from the scope of the present invention. For example, actuators **24** may be attached to front suspension towers (not shown). Actuators **24** may be powered by any appropriate source of power, such as electromechanical, pneumatic, hydraulic or pyrotechnic, all of which are well known in the art.

As is well known in the art, vehicle **10** may be equipped with one or more sensors **28** (indicated schematically in FIGS. **3** and **4**) which sense an actual and/or imminent and/or probable collision between the vehicle and a pedestrian. Sensor **28** may, for example, be a contact sensor mounted directly to the front surface of the vehicle (the bumper, for example) for detecting an actual collision. Alternatively or additionally, the sensor **28** may comprise a remote sensor, such as an optical, radar, lidar (also known as laser radar), or ultrasonic sensing system for detecting an impending or possible collision based upon the presence and/or dynamic state of a pedestrian and/or other object in the environment prior to contact with the vehicle. Any combination of the remote or contact sensors may be used in combination to provide accurate and reliable collision and/or pre-collision sensing.

Based (at least in part) on inputs from the sensor(s) **28**, an electronic control module (ECM) **30** activates one or more safety devices or systems to reduce the likelihood and/or severity of injury to the pedestrian. One such known pedestrian safety system activates latch mechanism **20** and/or other actuators (not shown) to move hood **12** to the raised condition prior to the pedestrian striking the hood. Compared with a closed hood, the raised condition provides increased vertical clearance between the hood and any rigid (non-yielding) objects in the engine compartment. Hood **12** may be engineered to yield or deflect so as to absorb kinetic energy of the impact, thereby providing an amount of cushioning. ECM **30** may control only pedestrian safety devices/systems, or it may also control or electronically interface with other vehicle

safety devices/systems, such as occupant restraints and collision warning/avoidance systems.

When an actual or impending collision with a pedestrian is detected by the sensor(s) **28**, ECM **30** triggers latch mechanism **20** (and/or other hood release/actuator devices) to release hood **12** and move it to the raised condition. When in the raised condition, hood leading edge **12A** is raised relative to the adjacent front surface of the vehicle to the form a gap **32** (see FIG. **4**) below the hood leading edge. Gap **32** is sufficiently large to allow stiffener **22** to project through, as described below. In one test vehicle, the hood is lifted approximately 40 mm.

The force to move hood **12** to the raised condition may be provided by springs or other appropriate devices associated with latch mechanism **20**. Additional or alternatively, hood lifting force may be provided by separate springs or actuators (not shown) located in the other positions in or near the engine compartment **14**.

Once hood leading edge **12A** has been lifted, actuators **24** are activated to extend actuator rods **24A** and thereby urge stiffener **22** to its deployed position wherein it projects through the gap **32** and is forward of the hood leading edge **12A** (see FIG. **4**). In the deployed position, stiffener **22** provides an improved transfer of kinetic energy to the upper leg of a pedestrian so as to reduce the likelihood and/or severity of injury. As seen in FIG. **4**, stiffener **22** may when deployed be positioned approximately even with the forward-most position of the vehicle front surface or bumper. The most advantageous position of stiffener **22** will depend on the overall geometry of the vehicle front end, and may be determined by computer modeling and/or testing using a leg-form to simulate pedestrian impacts, as is well known in the art.

Stiffener **22** may be fabricated from any appropriate material as necessary to achieve desired mechanical characteristics (strength, impact absorption, etc.). Examples of such materials include aluminum, steel, fiber reinforced plastic, and/or other composites. Actuators **24** and/or actuator rods **24A** may be designed to absorb collision energy by any appropriate means, such as springs, pneumatics, elastic and/or plastic deformation, etc.

The axis along which stiffener **22** is deployed by actuators **24** is shown in FIGS. **3** and **4** as being generally parallel with the longitudinal axis of the vehicle **10**, or horizontal when the vehicle is on a flat, horizontal road surface. The deployment axis may, however, be angled upward or downward with respect to the vehicle longitudinal axis. This may, for example, be required to provide proper positioning of the deployed stiffener and/or to permit efficient mounting/packaging when retracted.

FIGS. **5** and **6** show an embodiment of a hood latch **20** comprising a mounting portion **40** for securing the latch to vehicle structure beneath hood **12**, a primary latch **42**, and a secondary latch **44**. Primary latch **42** is rotatable about pivot axis **P1** and is retained in the latched position shown in FIG. **5** by engagement with a release pawl **46**. Primary latch **42** holds striker **21** in the full-down position to secure hood **12** in the fully closed position. In this position, spring **48** is in tension and applies a clockwise (as viewed in FIGS. **5** and **6**) rotational force to primary latch **42**.

A hood latch actuator **50** (such as a solenoid or a voice-coil) extends to apply force to release pawl **46**, rotating it counter-clockwise (about pivot axis **P2**) and thereby unlocking primary latch **42**. When unlocked, spring **48** shortens and rotates primary latch **42** clockwise to the position shown in FIG. **6** wherein the primary latch urges striker **21** upward against secondary latch **44**. The vertical distance travelled by striker **21** between the FIG. **5** and FIG. **6** positions lifts hood **12** to the

5

raised condition (see FIGS. 1 and 3). An alternative mounting for a hood latch actuator 50A is indicated in phantom lines.

Hood latch actuator 50 is, like the stiffener actuators 22, activated by ECM 30 in response to an actual and/or predicted collision with a pedestrian. Actuator 50 may also be activated manually by a control (not shown) in the passenger compartment when a vehicle operator desired to open the hood 12 for inspection or servicing. The secondary latch 44 may be manually actuated to open the hood 12 beyond the raised position, as is well known in the art.

Stiffener 22 may be shaped to follow or match the contour of hood leading edge 12A and/or a contour of the vehicle front structure (the grille, for example) immediately below the leading edge. In the illustrated embodiment, for example, the lateral midpoint (relative to vehicle 10) is the lowest and forward-most point of stiffener 22, and it curves upward and rearward towards both its left and right ends, matching the shape of hood leading edge 12A. This allows the stiffener 22 to be located as far forward as possible when in the retracted position and thereby minimize the travel distance required to reach the deployed position.

Depending upon the construction and desired appearance of the vehicle, it is possible for stiffener 22 to be exposed beneath the hood leading edge 12A when the stiffener is retracted and the hood is closed. For example, a front surface of stiffener 22 may be visible (to a person positioned generally forward of the vehicle) to create an ornamental trim-line between hood leading edge 12A and grille 16 or other component(s) included in the front structure of the vehicle. A configuration in which some portion of the retracted stiffener 22 is visible beneath the leading edge of the closed hood 12 is included in the present description referring to stiffener 22 as being "beneath" the hood.

Actuators 24 may be capable of returning to the retracted position after an actuation, a feature commonly referred to as being "resettable." If stiffener 22 is deployed in response to an expected/predicted pedestrian impact that does not actually occur, the reset feature is employed to return the stiffener to its retracted position. The reset of stiffener 22 may be performed upon a command from the vehicle operator and/or after a set amount of time has elapsed since stiffener deployment.

While exemplary embodiments are described above, it is not intended that these embodiments describe all possible forms of the invention. Rather, the words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the invention. Additionally, the features of various implementing embodiments may be combined to form further embodiments of the invention.

What is claimed is:

1. Pedestrian protection apparatus for a motor vehicle comprising:

- a hood movable between a closed condition and a raised condition wherein the hood is raised relative to a front surface of the vehicle forming a gap between a leading edge of the hood and the front surface; and
- a transverse bar movable between a retracted position wherein it is beneath the hood in the closed condition and a deployed position wherein the bar projects through the gap and is disposed forward of the hood leading edge in the raised condition.

2. The apparatus of claim 1 further comprising an actuator moving the bar between the retracted and deployed positions.

3. The apparatus of claim 2 wherein the actuator is one of a pneumatic, a pyrotechnic, and an electromechanical actuator.

6

4. The apparatus of claim 2 further comprising a remote sensing system detecting an impending collision with a pedestrian and triggering the actuator in reaction to the impending collision.

5. The apparatus of claim 2 wherein the actuator is operable to return the bar to the retracted position after deployment.

6. The apparatus of claim 2 wherein the actuator is mountable to a radiator support structure of the vehicle.

7. The apparatus of claim 1 further comprising a hood lifting device operable to move the hood to the raised condition.

8. The apparatus of claim 1 wherein the bar is shaped to follow a contour of the hood leading edge.

9. The apparatus of claim 1 wherein the bar is shaped to follow a contour of the front surface immediately below the hood.

10. A safety system for use with a motor vehicle, comprising:

- a hood movable between a closed position and a raised position wherein a leading edge of the hood is raised relative to a front surface of the vehicle to form a gap between the leading edge and the front surface;
- a leg stiffener movable between a retracted position wherein it is beneath the hood when the hood is closed and a deployed position wherein the stiffener projects through the gap and is forward of the leading edge of the hood when the hood is raised;
- an actuator moving the stiffener between the retracted and deployed positions; and
- a remote sensing system detecting an impending collision with a pedestrian, the actuator triggered when the impending collision is detected.

11. The system of claim 10 wherein the actuator is one of a pneumatic, a pyrotechnic, and an electromechanical actuator.

12. The system of claim 10 wherein the actuator is operable to return the stiffener to the retracted position after deployment.

13. The system of claim 10 wherein the actuator is mountable to a radiator support structure of the vehicle.

14. The system of claim 10 further comprising a hood lifting device operable to move the hood to the raised position.

15. The system of claim 10 wherein the stiffener is shaped to follow a contour of the hood leading edge.

16. Apparatus for a motor vehicle, comprising:

- a leg stiffener mounted beneath a vehicle hood and movable between a retracted position beneath the hood when the hood is closed and a deployed position extending forward of a leading edge of the hood and through a gap between the leading edge and a vehicle front surface when the hood is in a raised position wherein the leading edge is raised relative to the vehicle front surface.

17. The apparatus of claim 16 further comprising an actuator moving the stiffener between the retracted and deployed positions.

18. The apparatus of claim 17 further comprising a remote sensing system detecting an impending collision with a pedestrian and triggering the actuator in reaction to the impending collision.

19. The apparatus of claim 17 wherein the actuator is mountable to a radiator support structure of the vehicle.

20. The apparatus of claim 16 wherein the stiffener is shaped to follow a contour of the hood leading edge.